Pacific Science (1996), vol. 50, no. 3: 274–284

Relative Abundance of Lizards and Marine Toads on Saipan, Mariana Islands[1]

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ABSTRACT: Twelve species of lizards and the marine toad (*Bufo marinus* L.) were surveyed in six habitat types at three sites on the island of Saipan, Mariana Islands, using visual censuses, hand captures, and adhesive traps. Toads were rare on each of the study sites. *Anolis carolinensis* Cuvier was most common in disturbed forests. Four species of geckos, *Gehyra mutilata* (Wiegmann), *G. oceanica* (Lesson), *Lepidodactylus lugubris* (Duméril & Bibron), and *Perochirus ateles* Duméril, were most abundant in forests and abandoned buildings, and a fifth species, *Hemidactylus frenatus* Duméril & Bibron, occurred most frequently on structures of all types and in open fields. The skink *Carlia fusca* Duméril & Bibron was the most abundant diurnal lizard in all habitats. *Emoia caeruleocauda* de Vis occurred in all habitat types surveyed except open fields and was usually much less common than *C. fusca*. *Emoia atrocostata* (Lesson) was documented for the first time on Saipan, with a population found on a small offshore islet with scrubby strand vegetation. *Lamprolepis smaragdina* (Lesson) was relatively common at only one of three study sites, where it was seen primarily on large tree trunks. *Varanus indicus* (Daudin) displayed broad habitat use, but also was common in only one study area. At least five of these species are introductions, with *C. fusca* suspected of causing population reductions of other terrestrial skinks on the island.

INCREASING ATTENTION has been focused on the diversity, abundance, and ecology of reptile and amphibian communities in the Mariana Islands of Micronesia (Sabath 1981, Wiles et al. 1989, 1990*b*, Rodda et al. 1991, Rodda and Fritts 1992). However, no studies have examined the herpetofauna of Saipan, which is the second largest and second most populous island in the archipelago. A better understanding of the reptiles on the island is desirable because of accelerated habitat loss associated with recent economic growth and the island's high risk of obtaining a breeding population of brown tree snakes [*Boiga irregularis* (Merrem)]. Saipan's reptile fauna is also of interest because of the introduction of several lizard species during the last few decades (Rodda et al. 1991). One of these species, the skink *Carlia fusca* Duméril & Bibron, has been implicated in the declines of native skinks elsewhere in the island chain (Rodda et al. 1991). Finally, most of Saipan is occupied by highly disturbed vegetation, which likely has altered its lizard populations. Native plant communities currently cover less than 8% of the island (Engbring et al. 1986). The goals of our study were to document lizard and marine toad (*Bufo marinus* L.) abundance and habitat use at several locations on Saipan.

Study Area

Saipan (15° 10′ N, 145° 45′ E) is located in the central Mariana Islands and has a land area of 123 km^2. The east-central portion of Saipan, where this study took place, is dominated by a series of rugged uplifted terraces and steep hillsides that culminate in a tall ridge running north-south along the center of the island. Maximum elevation is 466 m.

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Surveys were made at three sites, Hakmang (=Kagman) Peninsula, Laolao Bay, and Kannat I Pitot, all located along or near the coast (Figure 1). Hakmang Peninsula consists of a large, low plateau bounded by coastal escarpments on several sides. A small island, Isleta Maigo Luao (=Forbidden Island), occurs off the southeastern tip of the peninsula, separated by a narrow, shallow channel (about 15–20 m wide at low tide) strewn with boulders. The island is 3.2 ha in area and has steep sides with a flattened

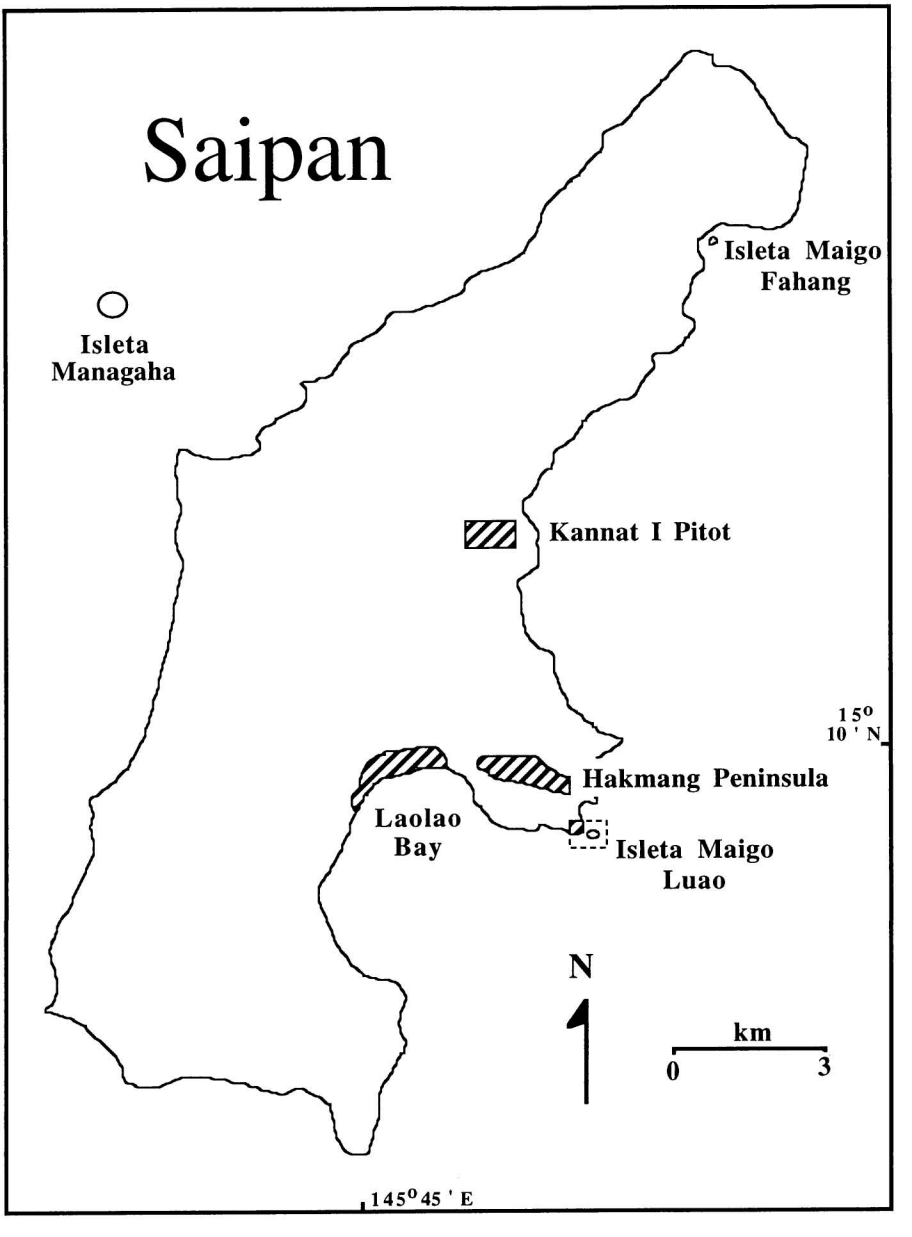

FIGURE 1. Map of Saipan, Mariana Islands, with locations of the three study sites.

summit at an elevation of 41 m. The locality at Laolao Bay features a narrow coastal flat bordered by steep hills to the north. Kannat I Pitot is composed of a gently sloping hillside cut by several small stream valleys. Elevations of the study sites occur from 0 to 150 m. Soils are thin and derived from limestone rock, except for one area of volcanic earth on the north side of Laolao Bay.

Saipan's climate is tropical and temperatures remain warm and relatively constant during the year, ranging from 22 to 33°C. Annual rainfall averages about 2000 mm, most of which falls from July to November (van der Brug 1985). A dry season occurs between January and May, when rain diminishes to a mean of about 90 mm per month.

Descriptions of plant communities on Saipan appeared in Fosberg (1960), Engbring et al. (1986), and Falanruw et al. (1989). Six habitat types were recognized for our study, with secondary forest and tangantangan [*Leuceana leucocephala* (Lam.) de Wit] forest being the most common communities. Secondary forest is variable in nature and is composed largely of introduced species. The most numerous trees are *Leucaena leucocephala*, *Acacia confusa* Merrill, *Albizia lebbeck* (L.) Bentham, *Cocos nucifera* L., *Carica papaya* L., *Barringtonia asiatica* L. (Kurz), and *Melanolepis multiglandulosa* Reinw., and *Mikania scandens* (L.) Willd and other vines are also common. The canopy ranges in height from 5 to 20 m, and the understory may be dense or relatively open.

Large, nearly pure forests of tangantangan grow on sizable portions of the study area. Canopy height is usually 4–5 m. The vines *Jasminum marianum* DC., *Mikania scandens*, and *Passiflora suberosa* L. are often present, and a dense herbaceous or grassy ground cover sometimes exists.

Limestone forest is characterized by sparse to moderate undergrowth, a canopy 10–15 m high, and scattered taller emergent trees. This vegetation type was found primarily on hillsides where clearing had not occurred in the past. Common tree species include *Cynometra ramiflora* L., *Barringtonia asiatica*, *Guamia mariannae* (Safford) Merrill, *Pisonia grandis* R. Brown, *Ochrosia mariannensis* A. DC., *Pandanus dubius* Sprengel, and *Premna obtusifolia* R. Brown. The vines *Flagellaria indica* L., *Jasminum marianum*, and *Alyxia torresiana* Gaudichaud were also common. Numerous rock outcrops and boulders typify this habitat.

Weedy open fields frequently occupy recent agricultural lands. Weed growth may be thick or fairly open, and 0.5–1.5 m high. Common plants are *Sida acuta* Burmann, fil., *Mimosa invisa* Martins, *Mikania scandens*, *Bidens alba* (L.) DC., *Lantana camara* L., *Stachytarpheta* sp., *Cassia alata* L., and *Chromolaena odorata*. An area of savanna with *Miscanthus floridulus* (Labill.) at Laolao Bay was lumped with this habitat category.

Strand vegetation occurs as a narrow band on limestone substrates along the shore of the ocean. It is usually stunted and windswept, being 0.5–3 m tall and commonly includes *Scaevola sericea* Vehl, *Wollastonia biflora* (L.) DC., *Pemphis acidula* Forst., *Zoysia matrella* (L.) Merrill, *Bikkia tetrandra* Brongniart, and *Ipomea pes-caprae* (L.) Roth. Bare rock faces and boulders are often present.

Abandoned concrete and tin buildings were a final habitat type. A few of these structures were located in secondary forest, tangantangan, or open fields on each study area. None were lighted.

Most of the study sites exhibited little evidence of cattle grazing, but a few fields and groves of tangantangan were apparently used regularly. This activity altered the amounts and types of ground cover and therefore potentially changed the lizard communities at a few locations.

MATERIALS AND METHODS

Field surveys were made on Hakmang Peninsula from 11 January to 3 February 1991, at Laolao Bay from 15 February to 14 April 1991, at Kannat I Pitot from 17 to 26 January 1992, and at Isleta Maigo Luao on 10 October 1992 and 20 August 1994. Count sites were selected to provide wide coverage of the common or unique natural habitats at each location. One or two observers participated in surveys at each site. Observers censused lizards by walking slowly through each

site and counting the number of animals seen on the ground and in trees. Every lizard observed was recorded by species, date, time, locality, microhabitat, and in the case of *Emoia caeruleocauda* de Vis, by the color of its tail and posterior portion of its body. Lizards not positively identified by sight during censuses were classified as being either unknown skinks or geckos. Animals were captured whenever possible to obtain accurate identifications. Skinks were caught by shooting them with a heavy rubber band; geckos were captured by hand. Species identities were determined with an unpublished identification key produced by G. H. Rodda and T. H. Fritts (pers. comm.). Most censuses took place between 0900–1600 and 1930–2400 hours. Lengths of censuses ranged from 15 to 120 min per site, with most lasting 45–60 min.

The abundance of skinks was also measured with adhesive rat traps (Victor Holdfast Glueboards, Woodstream Corp., Lititz, Pennsylvania) in most habitats at each study site. Traps were 12 by 16 cm in size and were placed 10–15 m apart on the ground. Ten or 20 traps were set per location. They were placed out at 0900–1200 hours and retrieved 4–5 hr later. The traps allowed the capture of lizards that were exceptionally wary and difficult to catch (Rodda et al. 1993). They also allowed us to sample the relative activity of species in a less subjective manner than visual censusing and hand collecting. Additional information about Saipan's reptiles and toads was gathered during incidental observations made outside of census periods.

SPECIES ACCOUNTS

One species of amphibian (*B. marinus*) and 11 species of lizards, including an anole, five geckos, four skinks, and a monitor lizard, were recorded during this study. Only one lizard species previously known from the island, the skink *Cryptoblepharus poecilopleurus* (Wiegmann), was not detected. Data from visual surveys and trapping were pooled for all three study sites because of the similarity in results.

BUFONIDAE

Bufo marinus L.

Marine toads were rare at each study site, with only a few individuals seen per location. Toads were recorded in all habitats except coastal strand and old buildings (Table 1). Hilly terrain and porous soils in the east-central part of the island probably result in a scarcity of breeding sites for this species. This was despite the presence of several ephemeral streams that ran through the Laolao Bay and Kannat I Pitot sites, which were expected to retain pools of standing water long enough to permit breeding and growth of tadpoles. *B. marinus* was introduced to Saipan by the Japanese in the late 1930s or early 1940s (Townes 1946).

IGUANIDAE

Anolis carolinensis Cuvier

This arboreal lizard was recorded in all plant communities except open fields, with observations most numerous in tangantangan and secondary forests (Table 1). Rates of detection were nearly equal during both day and night. Although anoles are active in the day, they were commonly found at night sleeping in the foliage of tangantangan, other small trees, shrubs, and vines. The first specimens of *A. carolinensis* on Saipan were collected in 1979 (National Museum of Natural History [USNM] 212383–212386), suggesting that the species arrived on the island sometime in the 1960s or 1970s.

GEKKONIDAE

Gehyra mutilata (Wiegmann)

This gecko displayed a wide range of habitat use, being found in all plant communities except fields and grasslands (Table 1). It was relatively common in each type of forest, but its highest densities were recorded on the walls of several old buildings and on rock outcroppings along a lengthy road cut

on the north side of the Laolao Bay study site. In forested sites, it was seen more often on small trees than on large ones, with rock faces little used.

Gehyra oceanica (Lesson)

This large species was the most abundant gecko in secondary and limestone forests (Table 1), where it typically inhabited rock outcrops, the trunks of large trees such as *Erythrina variegata* L., *Barringtonia*, *Cocos*, *Albizia*, *Acacia*, and *Ficus prolixa* Forst., the heavy broad leaves of *Pandanus dubius*, and the fronds of *Cocos*. Similar substrate use was noted on the neighboring island of Rota (Wiles et al. 1990*b*). A few animals were found on smaller trees, especially where loose flaking bark was present to provide daytime hiding sites. *G. oceanica* was also common on the walls of several old buildings.

Hemidactylus frenatus Duméril & Bibron

This introduced species is commonly associated with human dwellings (McCoy 1980, Sabath 1981, Zug 1991, Petren et al. 1993). We found it to be the most common gecko on abandoned buildings and in open fields (Table 1), where it occurred on isolated trees, shrubs, and rocks. On Hakmang Peninsula, several individuals were also caught in a grove of tangantangan forest within 10–75 m of an empty building inhabited by numerous *H. frenatus*. It was absent from other plant communities. These results suggest that the species is largely excluded from vegetated habitats where other species of geckos are present. Observations at homes and other artificially lighted structures in more urbanized parts of the island revealed that *H. frenatus* was generally the most abundant gecko at these sites.

Lepidodactylus lugubris (Duméril & Bibron)

Lepidodactylus lugubris displayed the broadest habitat use of any gecko and was found in all vegetation types and on buildings (Table 1). However, it was common only in tangantangan forest, where it was the most abundant species present. Substrates used were mainly tangantangan and other small trees. *Lepidodactylus lugubris* was also fairly common on abandoned buildings, although less abundant than three other gecko species. Elsewhere on the island, it was regularly found on lighted buildings but was much less

TABLE 1

RATES OF OBSERVATIONS OF LIZARDS AND MARINE TOADS IN RELATION TO HABITAT AND TIME OF DAY ON EASTERN SAIPAN, MARIANA ISLANDS

HABITAT	SEARCH EFFORT (HR)	RATES OF OBSERVATION (ANIMALS/HR)[a]						
		Anolis carolinensis	*Gehyra mutilata*	*Gehyra oceanica*	*Hemidactylus frenatus*	*Lepidodactylus lugubris*	*Perochirus ateles*	UNKNOWN GECKOS
Day								
Secondary forest	11.8	0.5	0.1	0	0	0.1	0	0
Tangantangan	12.0	0.6	0	0	0	0.1	0	0
Limestone forest	9.8	0.1	0.1	0	0	0	0.1	0
Strand	6.0	0.2	0	0	0	0	0	0
Open field/savanna	6.0	0	0	0	0	0	0	0
Night								
Old buildings	1.8	0	9.4	10.6	19.4	5.0	0	7.2
Limestone forest	10.8	0.5	1.7	3.2	0	0.2	0.2	0.7
Tangantangan	11.0	0.6	1.1	0.3	0.3	1.9	0	1.5
Secondary forest	13.3	0.7	1.1	1.7	0	0.6	0.2	1.2
Open field/savanna	7.3	0	0	0	1.1	0.1	0	0.4
Strand	5.0	0.2	0.4	0	0	0.4	0	0.2

[a] Number of animals seen per hour by each person.
[b] Recorded in this habitat during incidental observations.

common than *H. frenatus*. Our survey results indicate that *L. lugubris* is less abundant on Saipan than on Rota, Tinian, and Guam, where it is one of the most numerous geckos (Sabath 1981, Wiles et al. 1989, 1990*b*, Rodda and Fritts 1992).

Perochirus ateles Duméril

Perochirus ateles was placed on the endangered species list of the Commonwealth of the Northern Mariana Islands in 1991, but there have been no published studies documenting its actual abundance. Only three specimens (USNM 212382, 257645, and 257659) are known to have been collected on Saipan since 1978.

We found *P. ateles* to be indeed rare, with only five individuals captured during this study. Three specimens were found at Hakmang Peninsula and two at Laolao Bay. Animals were collected only in limestone and secondary forests, where they were recorded in about equal abundance (Table 1). Capture sites in limestone forest included a large rock outcrop that was 20 m long and 3–5 m high, where two individuals were found, and under a piece of loose bark on a dead tangantangan tree with a trunk diameter of 15 cm, which one animal used as a diurnal shelter. In secondary forest, this species was caught among the leaves of a large *Acacia* tree and on the frond of a coconut palm. Data from previously collected museum specimens indicate that buildings are also used (e.g., the inside of a house in San Vicente and an old Japanese bunker at Kannat Makpe). These records plus our captures suggest that the species is widely distributed on the island.

The only other extant population of *P. ateles* in the Marianas remains on Cocos Island off the southern coast of Guam (McCoid and Hensley 1994). The species has not been recorded from Tinian since 1946 (Wiles et al. 1989) or from Guam since 1978 (Rodda and Fritts 1992). The population on Guam is believed to have been extirpated because of intense predation by brown tree snakes (Rodda and Fritts 1992).

SCINCIDAE

Carlia fusca Duméril & Bibron

This was the most abundant skink at each study site. It occurred in all habitats, with the greatest numbers present in secondary forest and tangantangan (Tables 1 and 2). *Carlia fusca* was also common in open fields, where it was regularly trapped, but never observed, under dense weedy ground cover. The highest

TABLE 1 (continued)

	RATES OF OBSERVATION (ANIMALS/HR)[a]							
HABITAT	*Carlia fusca*	*Emoia caeruleocauda*	*Emoia atrocostata*	*Lamprolepis smaragdina*	UNKNOWN SKINKS	*Varanus indicus*	*Bufo marinus*	TOTAL
Day								
Secondary forest	14.2	3.1	0	0.4	5.3	0[b]	0.1	23.8
Tangantangan	9.8	0.8	0	0.2	2.9	0.1	0.2	14.6
Limestone forest	6.2	1.9	0	0.1	3.3	0.1	0[b]	11.9
Strand	0.8	0.2	0.8	0	0.7	0	0	2.7
Open field/savanna	0	0	0	0	1.3	0[b]	0[b]	1.3
Night								
Old buildings	0	0	0	0	0	0	0	51.6
Limestone forest	0	0	0	0.2	0	0	0.2	6.9
Tangantangan	0.1	0	0	0	0	0	0	5.8
Secondary forest	0	0	0	0.2	0	0	0[b]	5.6
Open field/savanna	0	0	0	0	0	0	0.5	2.2
Strand	0	0	0	0	0	0	0	1.2

TABLE 2

DAYTIME CAPTURE RATES OF SKINKS CAUGHT ON ADHESIVE TRAPS IN FIVE HABITATS ON EASTERN SAIPAN, MARIANA ISLANDS

HABITAT	NO. OF TRAP SITES	NO. OF TRAP HOURS	NO. OF ANIMALS CAPTURED/ TRAP HOUR	NO. OF SKINKS CAPTURED/TRAP HOUR		
				Carlia fusca	*Emoia caeruleocauda*	*Emoia atrocostata*
Secondary forest	6	300	0.207	0.197	0.010	0
Tangantangan	5	265	0.166	0.162	0.004	0
Open field/savanna	4	290	0.134	0.134	0	0
Strand	4	310	0.065	0.045	0	0.019
Limestone forest	3	220	0.064	0.064	0	0

relative abundance of *C. fusca* at any trapping site occurred in a field at Kannat I Pitot, where a remarkable mean capture rate of 0.48 animals per trap hour ($n = 50$) was obtained.

This introduced skink was first recorded on Saipan in the early 1960s by Dryden and Taylor (1969), who stated that it was already fairly common near the villages of San Roque and Koblerville. These sites are about 15 km apart, suggesting that *C. fusca* was also widespread by then. This indicates that the species probably invaded the island during the 1950s.

Emoia caeruleocauda de Vis

Blue-tailed skinks were recorded in all habitats except open fields and savanna, but were most abundant in secondary and limestone forests (Tables 1 and 2). Their distribution was often patchy: they were common at a few locations but rare or absent in most areas. Overall, this species was much less common than *C. fusca* at each of the study sites. Among three forest communities, observation rates of *C. fusca* were significantly higher than for *E. caeruleocauda* in tangantangan ($\chi^2 = 93.6$, df = 1, $P < 0.0001$, $n =$ 127, sightings of both species), secondary forest ($\chi^2 = 83.7$, df = 1, $P < 0.0001$, $n =$ 205), and limestone forest ($\chi^2 = 22.1$, df = 1, $P < 0.0001$, $n = 80$) (Table 1). Comparative abundance based on trapping results was even more disparate, with only four *E. caeruleocauda* captured versus 116 *C. fusca* in all forests (Table 2).

Emoia caeruleocauda was usually observed on the ground, but it occasionally foraged up to 1.2 m high in low vegetation. There was also a tendency for this species to occur more frequently at microsites with dense ground cover. Wiles et al. (1990*b*) noted similar feeding behavior on Rota. Half of all individuals featured the blue tails characteristic of juveniles and at least some older females, and half had brown tails ($n = 58$).

Emoia atrocostata (Lesson)

A comparatively dense population of *E. atrocostata* was discovered on Isleta Maigo Luao, the first time this species has been documented for Saipan. Most individuals occurred among the boulders and dense zone of *Pemphis* shrubs next to the shoreline and on an adjacent soil slope covered by *Wollastonia* vines at 8–25 m elevation. Six animals were captured on 20 adhesive traps during a total of 80 trap hours, and five others were seen in 1 hr of searching. Animals were recorded more commonly in the *Pemphis* community. This species was less abundant on the island's upper plateau, which features low grass and shrubs, with only one individual caught on 20 traps (total of 40 trap hours). *Emoia atrocostata* was generally quite wary, with animals never seen far from protective cover while foraging and sunning. Snout-vent lengths and total lengths of five voucher specimens (USNM 328689–328693) averaged

49.2 mm (range, 38–61 mm) and 122.6 mm (range, 108–146 mm), respectively.

Elsewhere in the Mariana Islands, this skink is known only from Rota, Cocos Island, and Aguiguan (Brown and Falanruw 1972, Wiles et al. 1990*b*; E. Campbell, pers. comm.). It appears to reside exclusively in supralittoral thickets of *Pemphis* on Rota and Cocos Island, but occurs among tufts of coastal grasses and rocks on Aguiguan.

Lamprolepis smaragdina (Lesson)

At Laolao Bay, *L. smaragdina* was fairly common in secondary forest, but less abundant in limestone and tangantangan forests. It was rare on Hakmang Peninsula and not observed at Kannat I Pitot. This species was usually seen climbing on the trunks of large trees such as *Cocos*, *Albizia*, *Artocarpus*, and *Erythrina*, but was also occasionally recorded on *Carica papaya* and tangantangan.

This large arboreal skink was probably introduced to Saipan in the 1960s or early 1970s. The first known specimens from the island were collected in 1978 (California Academy of Sciences 152034) at an unidentified site and in 1979 (USNM 212466–212486) at Oleai near the village of San Jose. A number of individuals were caught at the second location, indicating that the species was already well established.

Cryptoblepharus poecilopleurus (Wiegmann)

We did not find this species, despite sampling strand communities at two of the study sites. *Cryptoblepharus poecilopleurus* was not recorded on either of our visits to Isleta Maigo Luao; however, five individuals were collected on top of the islet in low grass on 10 February 1993 (T. H. Fritts, pers. comm.). The only other specimens known from Saipan were captured in 1963 by Dryden and Taylor (1969), but they provided no information on collecting locality or habitat. This species typically inhabits coastal vegetation on most other islands in the archipelago (Wiles et al. 1990*b*, Rodda et al. 1991, McCoid et al. 1995) and likely resides in this habitat elsewhere on Saipan. There is an undocumented sighting from 1993 of this lizard among coastal boulders in the Makpe (=Marpi) region near the northern end of the island (R. J. Craig, pers. comm.).

VARANIDAE

Varanus indicus (Daudin)

Monitor lizards were common at Kannat I Pitot, with seven sightings made. Most were seen walking on narrow dirt roads outside census periods, but one juvenile was found sleeping at night in a hollow metal fence post. *Varanus indicus* was judged as rare or uncommon at the other study sites. Overall, they were recorded in all habitats except strand (Table 1).

DISCUSSION

Although this study covered a limited area of eastern Saipan, our results are probably representative of the lizard community in nonurban environments on much of the island. Several brief daylight surveys in forests in the north and north-central parts of the island confirmed that *C. fusca* was much more common than other species of skinks.

Gecko diversity was highest in the three forest types and on abandoned buildings, with each habitat having four species present (Table 1). *Gehyra mutilata*, *G. oceanica*, and *L. lugubris* displayed the broadest range in habitat use. Each occurred in at least four plant communities, including both disturbed and undisturbed habitats. In contrast, *P. ateles* was found only in limestone and secondary forests. In terms of overall abundance among the various vegetation types, gecko numbers were highest in the three kinds of forest (Table 1).

Each of the forest communities and shoreline strand contained three of the four species of skinks recorded in this survey (Table 1). Open fields and savanna held just one species. *Carlia fusca* was the only skink to occur in all five habitat types, whereas *E. caeruleocauda* inhabited all plant communities ex-

cept open fields. *Emoia atrocostata* was the most specialized species in its habitat use, being restricted entirely to strand vegetation. When observation rates and trapping success were combined for all species, skink abundance was greatest in secondary forest (Tables 1 and 2).

A large portion of Saipan's herpetofauna is probably introduced. Populations of *A. carolinensis*, *C. fusca*, and *L. smaragdina* have become established in the last few decades. *B. marinus* was brought to the island 50–60 yr ago. The arrival of *H. frenatus* is undocumented. Other species (*G. mutilata*, *G. oceanica*, *L. lugubris*, *C. poecilopleurus*, and *V. indicus*) may be much older introductions (Brown 1956, Case and Bolger 1991*a*, Zug 1991, Beckon 1992, Moritz et al. 1993) that arrived with Chamorro islanders, who have inhabited the Marianas for about 3500 yr, or with early European ship traffic.

Carlia fusca was ubiquitous and the most common diurnal lizard on each of our study sites, with the exception of Isleta Maigo Luao. Originally from the New Guinea region, it clearly has become the dominant terrestrial skink on Saipan since its introduction. It has reached similar levels of abundance on other Mariana Islands where it is now established (Tinian [Wiles et al. 1989], Guam [Rodda and Fritts 1992], and Cocos Island [Rodda et al. 1991]).

The introduction of *C. fusca* to the southern Marianas has coincided with, and may be directly linked to, population declines of *E. caeruleocauda* and possibly local extirpations of *E. atrocostata* and *C. poecilopleurus* during the last few decades (Rodda et al. 1991). There are little historic data on the abundance and distribution of these species before the arrival of *C. fusca*, making it difficult to judge the impact caused by its presence. Such an assessment is further confounded by the presence of the musk shrew (*Suncus murinus*), which was introduced to Saipan, Tinian, and Guam in the 1950s and 1960s (Peterson 1956, Barbehenn 1974, Wiles et al. 1990*a*). Shrews also were reported on Rota in the 1960s (Barbehenn 1974), but the population has died out (G. J. Wiles, pers. obs.; D. Worthington, pers. obs.). Shrew predation on ground-dwelling lizards could be severe (Barbehenn 1974, Rodda and Fritts 1992) and possibly impact population levels of some species.

Emoia caeruleocauda was presumably the most common skink on Saipan before the 1950s, as it once was on Tinian (Downs 1948), and remains so on Rota and Aguiguan, where *C. fusca* has not yet invaded (Wiles et al. 1990*b*, Craig and Chandran 1992). *Emoia caeruleocauda* also continues to be fairly common in some forested areas on Guam, despite the presence of *C. fusca*, but has generally declined on that island as well (Rodda and Fritts 1992).

On Saipan, *E. atrocostata* is currently known only from the small islet of Isleta Maigo Luao, which is separated from the main island by a narrow channel that is only 15–20 m wide and 10–30 cm deep at low tide. *Emoia atrocostata* is common on the islet, whereas *C. fusca* is common in similar strand habitat on the opposite shore. Water from nearby breaking surf and tidal surge washes rapidly through the channel and apparently creates a barrier sufficient to prevent the crossing of *C. fusca*, despite the presence of several large boulders and small rocks in the channel that could act as stepping stones for the lizard.

Ecological displacement of other skink species by *C. fusca* may have resulted from competitive interactions, predation, or a combination of factors. Dense populations of *C. fusca* may reduce the prey base of the other species. *Carlia fusca* is aggressive and physically larger than *E. caeruleocauda* and *C. poecilopleurus*. It will readily steal food from other lizards (Rodda et al. 1991) and has been observed to prey on juvenile *E. caeruleocauda* (J. Engbring in Wiles et al. 1989). In addition to its bold behavior, *C. fusca* is a habitat generalist, occurring in virtually all habitats, including forests, open areas, shorelines, and urban settings. In a review of interactions between native and introduced lizards on islands, Case and Bolger (1991*a*,*b*) found that changes in distribution and abundance of native species can often result, but that extinctions due to interspecific competition have yet to be documented. Biologists should be alert to the colonization of other Pacific islands by *C. fusca*. This skink ap-

pears capable of radically changing lizard communities on islands that it reaches.

Brown tree snakes are not yet known to be firmly established on Saipan, although a number of reported sightings from 1990 to 1994 suggests that a small population now occurs on the island (McCoid and Stinson 1991, Gomez 1993; E. Beyer, pers. comm.). The likelihood of snakes eventually forming a breeding population is high, because of the volume of ship cargo and airline flights passing from Guam to Saipan. During our study, no snakes were encountered in nearly 50 hr of nighttime searching. However, two reports of snakes in the Lourdes and Papago areas of eastern Saipan were received in 1992 (Gomez 1993). On Guam, predation by brown tree snakes is implicated in the extirpation or decline of *G. mutilata*, *G. oceanica*, *P. ateles*, and possibly several other lizard species (Rodda and Fritts 1992).

Additional surveys are needed on the rest of Saipan to clarify the status of the three rarest species, *P. ateles*, *E. atrocostata*, and *C. poecilopleurus*. *Perochirus ateles* is probably widespread, and both skinks are considered shoreline specialists. A 1-hr visual search for *E. atrocostata* and *C. poecilopleurus* was made at Isleta Maigo Fahang (=Bird Island), another small near-shore islet located 12 km north of Isleta Maigo Luao. No skinks of any species were seen, but a more intensive survey is needed to verify their absence. A similar survey also should be made on Isleta Managaha on the west coast of Saipan. If one or both species are absent, and *C. fusca* is not present, consideration should be given to translocating populations of both species to these small islands.

Rodda et al. (1991) gave limited evidence for the possible occurrence of a tree frog [*Litoria fallax* (Peters)] and the rock gecko [*Nactus pelagicus* (Girard)] on Saipan. Neither species was encountered in this study and their occurrence on the island remains conjectural.

ACKNOWLEDGMENTS

We thank R. E. Beck, D. R. Hopper, C. F. Aguon, and G. J. Witteman for their assistance with various parts of the study. G. H. Rodda, S. W. Gotte of the USNM, and J. V. Vindum of the CAS helped greatly by providing museum data on specimens previously collected on Saipan. L. Raulerson and A. Rinehart assisted with plant identification. R. J. Craig, D. W. Stinson, and E. Campbell reviewed the manuscript. Louis B. Wiles supported other aspects of the study.

LITERATURE CITED

BARBEHENN, K. R. 1974. Recent invasions of Micronesia by small mammals. Micronesica 10:41–50.

BECKON, W. N. 1992. The giant Pacific geckos of the genus *Gehyra*: morphological variation, distribution, and biogeography. Copeia 1992:443–460.

BOLGER, D. T., and T. J. CASE. 1992. Intra- and interspecific interference behaviour among sexual and asexual geckos. Anim. Behav. 44:21–30.

BROWN, W. C. 1956. The distribution of terrestrial reptiles in the islands of the Pacific basin. 8th Pac. Sci. Congr. Proc. 3A:1479–1491.

BROWN, W. C., and M. V. C. FALANRUW. 1972. A new lizard of the genus *Emoia* (Scincidae) from the Marianas Islands. Proc. Calif. Acad. Sci. 39:105–110.

CASE, T. J., and D. T. BOLGER. 1991*a*. The role of introduced species in shaping the distribution and abundance of island reptiles. Evol. Ecol. 5:272–290.

———. 1991*b*. The role of interspecific competition in the biogeography of island lizards. Trends Evol. Ecol. 6:135–139.

CRAIG, R. J., and R. CHANDRAN. 1992. Wildlife species recorded during the Aguiguan expedition: 20–25 May, 1992. Pages 1–7 *in* R. J. Craig, ed. The Aguiguan expedition. Proc. Marianas Res. Symp., Vol. 1.

DOWNS, T. 1948. Amphibians and reptiles of Tinian Island. Trans. Kans. Acad. Sci. 51:112–116.

DRYDEN, G. L., and E. H. TAYLOR. 1969. Reptiles from the Mariana and Caroline Islands. Univ. Kans. Sci. Bull. 48:269–279.

ENGBRING, J., F. L. RAMSEY, and V. J. WILDMAN. 1986. Micronesian forest bird survey, 1982: Saipan, Tinian, Agiguan, and Rota. U.S. Fish Wildl. Serv., Honolulu.

FALANRUW, M. C., T. G. COLE, and A. H. AMBACHER. 1989. Vegetation survey of Rota, Tinian, and Saipan, Commonwealth of the Northern Mariana Islands. U.S. For. Serv. Resour. Bull. PSW-27.

FOSBERG, F. R. 1960. The vegetation of Micronesia. Bull. Am. Mus. Nat. Hist. 119: 1–75.

GOMEZ, D. M. 1993. Brown tree snake control and interdiction. Pages 325–338 *in* Five-year progress report, fiscal years 1988–1992, Pittman-Robertson Federal Aid in Wildlife Restoration Program. Commonwealth of the Northern Mariana Islands Division of Fish and Wildlife, Saipan.

MCCOID, M. J., and R. A. HENSLEY. 1994. Distribution and abundance of *Perochirus ateles* (Gekkonidae) in the Mariana Islands. Herpetol. Rev. 25: 97–98.

MCCOID, M. J., and D. W. STINSON. 1991. Recent snake sightings in the Mariana Islands. Elepaio 51: 36–37.

MCCOID, M. J., G. H. RODDA, R. A. HENSLEY, and T. H. FRITTS. 1995. Habitat selection by *Cryptoblepharus poecilopleurus* (Scincidae) in the Mariana Islands. Micronesica 28: 103–108.

MCCOY, M. 1980. Reptiles of the Solomon Islands. Wau Ecol. Inst. Handb. No. 7.

MORITZ, C., T. J. CASE, D. T. BOLGER, and S. DONNELLAN. 1993. Genetic diversity and the history of Pacific island house geckos (*Hemidactylus* and *Lepidodactylus*). Biol. J. Linn. Soc. 48: 113–133.

PETERSON, G. D. 1956. *Suncus murinus*, a recent introduction to Guam. J. Mammal. 37: 278–279.

PETREN, K., D. T. BOLGER, and T. J. CASE. 1993. Mechanisms in the competitive success of an invading sexual gecko over an asexual native. Science (Washington, D.C.) 259: 354–358.

RODDA, G. H., and T. H. FRITTS. 1992. The impact of the introduction of the colubrid snake *Boiga irregularis* on Guam's lizards. J. Herpetol. 26: 166–174.

RODDA, G. H., T. H. FRITTS, and J. D. REICHEL. 1991. The distributional patterns of reptiles and amphibians in the Mariana Islands. Micronesica 24: 195–210.

RODDA, G. H., M. J. MCCOID, and T. H. FRITTS. 1993. Adhesive trapping II. Herpetol. Rev. 24: 99–100.

SABATH, M. D. 1981. Gekkonid lizards of Guam, Mariana Islands: Reproduction and habitat preference. J. Herpetol. 15: 71–75.

TOWNES, H. K. 1946. Entomology. Pt. 1. Non-agricultural plants. Economic Survey of Micronesia, Vol. 12. U.S. Commercial Co., Honolulu.

VAN DER BRUG, O. 1985. Compilation of water resources development and hydrologic data of Saipan, Mariana Islands. U.S. Geological Survey, Water Resources Investigative Report 84-4121.

WILES, G. J., A. B. AMERSON, JR., and R. E. BECK, JR. 1989. Notes on the herpetofauna of Tinian, Mariana Islands. Micronesica 22: 107–118.

———. 1990*a*. The mammals of Tinian, Mariana Islands. Micronesica 23: 167–180.

WILES, G. J., G. H. RODDA, T. H. FRITTS, and E. M. TAISACAN. 1990*b*. Abundance and habitat use of reptiles on Rota, Mariana Islands. Micronesica 23: 153–166.

ZUG, G. R. 1991. The lizards of Fiji: Natural history and systematics. Bishop Mus. Bull. Zool., No. 2.